

# Scene Understanding for High Resolution SAR

Mihai Datcu  
DLR Oberpfaffenhofen

## Report Documentation Page

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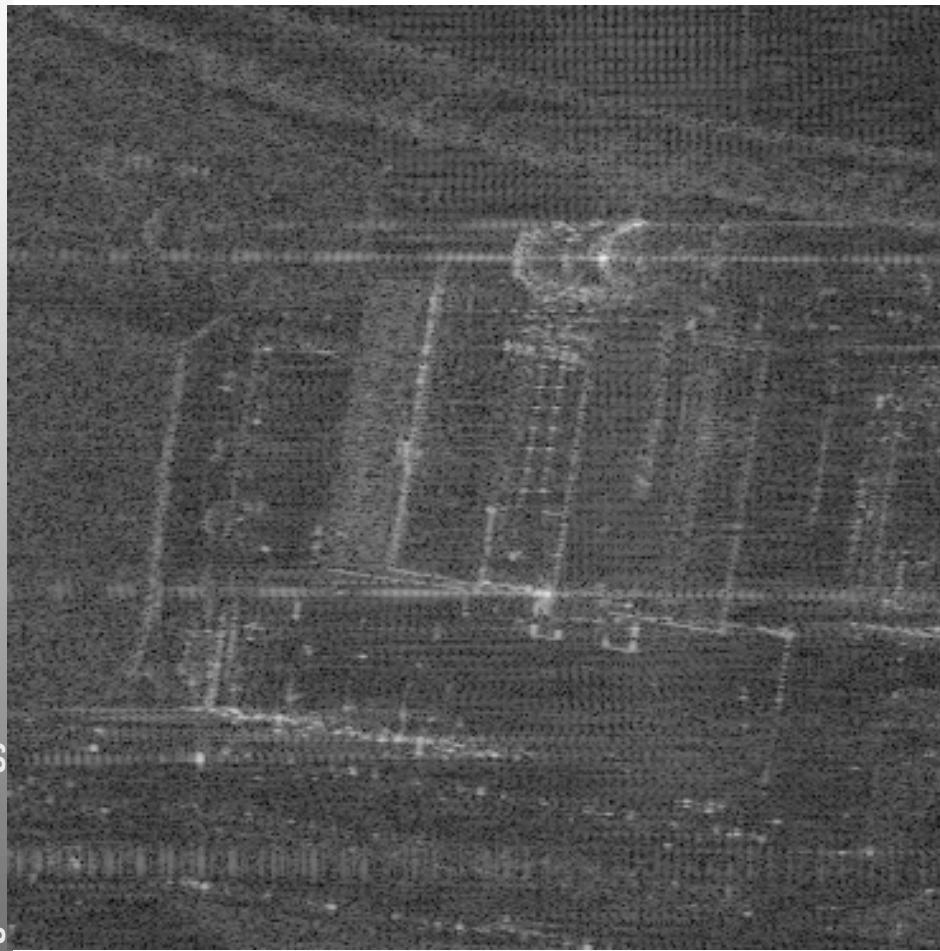
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# Objectives

Resolution	30-10m	10-5m	1m	10cm
Nature objects and scenes	Backscatter amplitude	Backscatter and some textures	Very important use of textures	
Man-made objects	Point of important signal	Some textures and some scatters	Geometrical interpretation using strong scatters	Only a composition of strong scatters
Developed theory	Well-known studies	Knowledge	?	Some research
Missions or used by...	ERS 1/2 RADARSAT		Only experimental airborne data	Military

TerraSAR

# Meter resolution SAR analysis



Interm ap Maastricht,  
0.5m

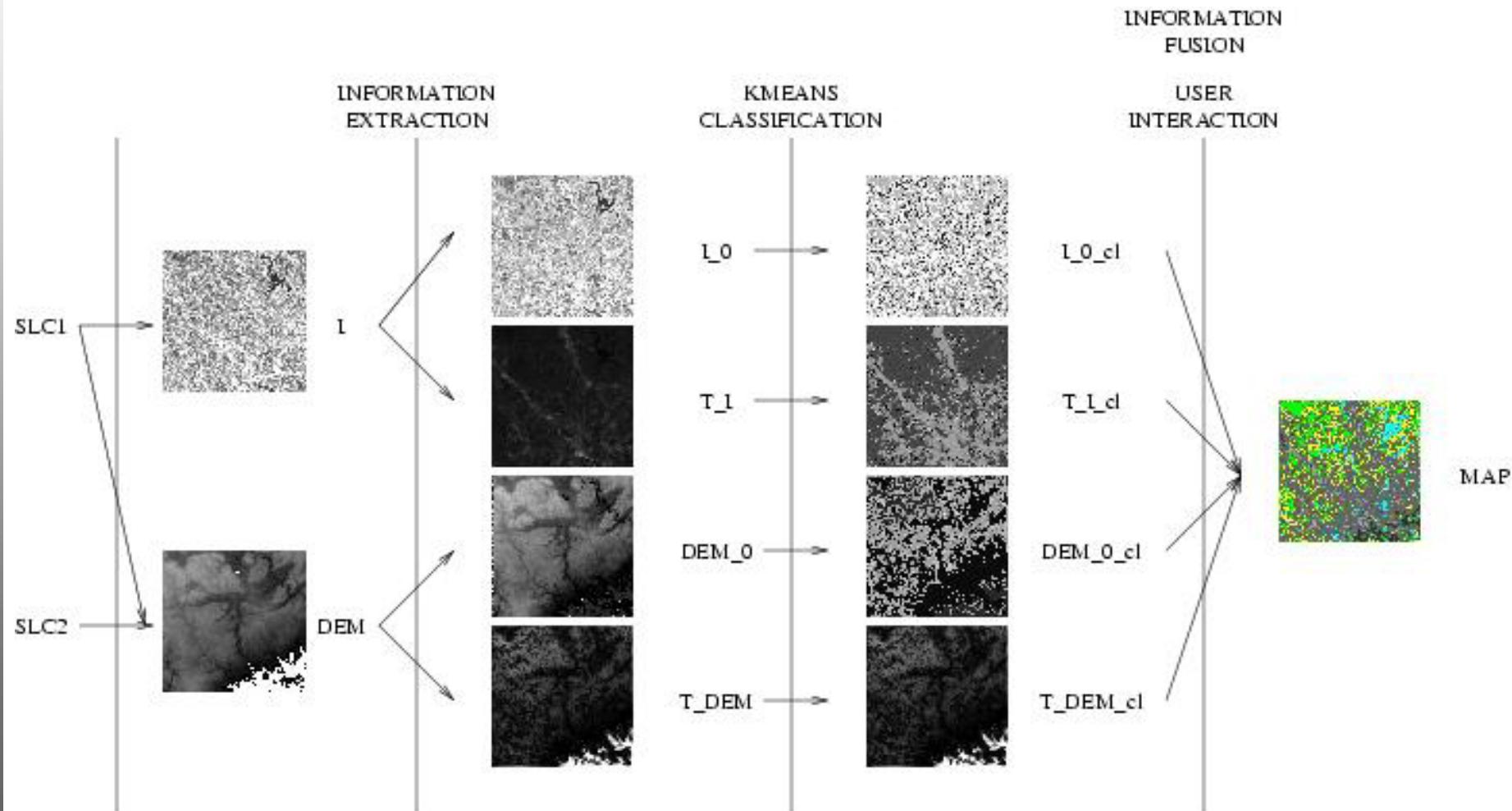
- Target detection  
*(adaptive CFAR, stability over series...)*
- Target characterization  
*(peak power & phase...)*
- Scattering studies  
*(scattering models, simulators...)*
- Target spectral analysis  
*(Wavenumber shift, range gates...)*
- EM Scattering  
*(target signatures...)*

Complex image analysis

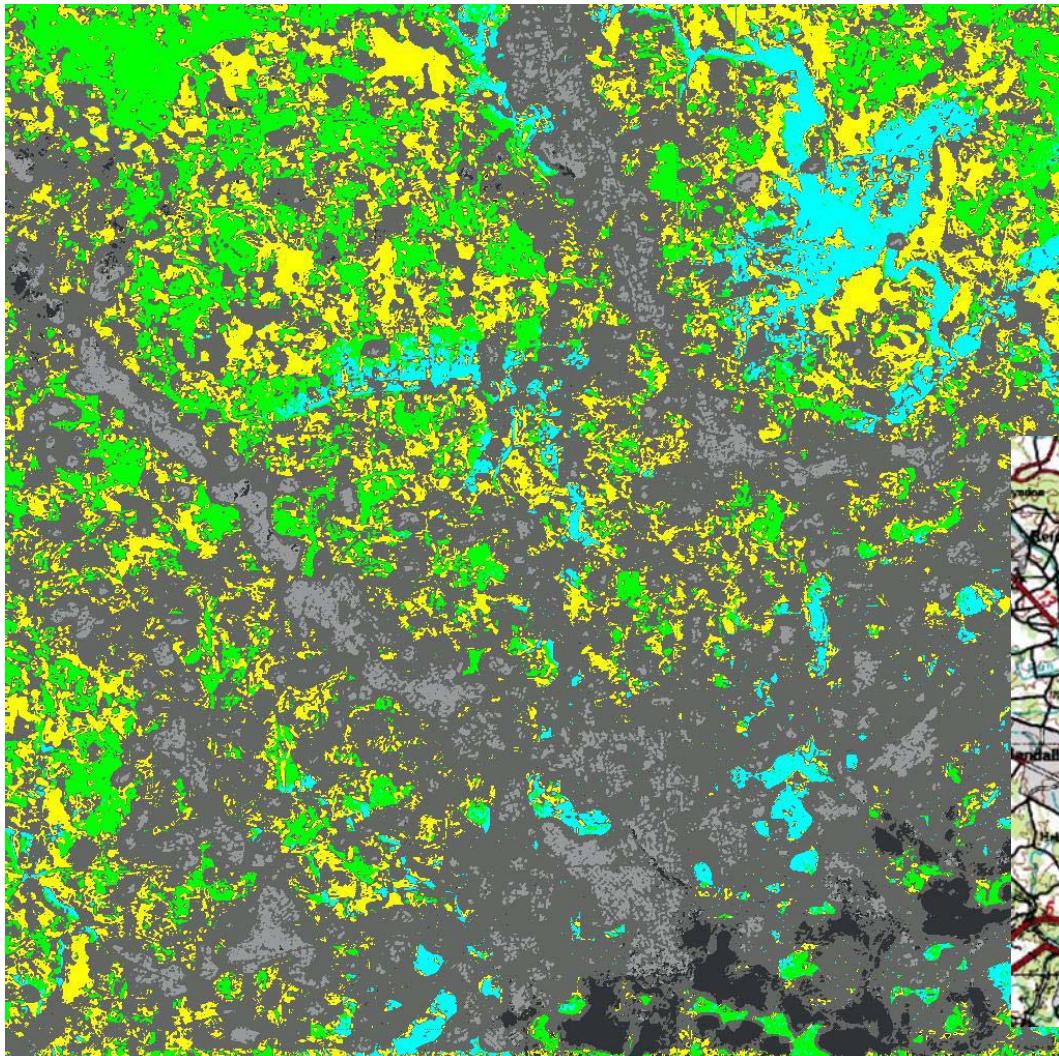
Scene & image formation phenomenology

1. Image Information Mining
2. Stochastic Geometrical Modeling and Estimation
3. Cepstrum Analysis
4. Fourier-Mellin Analysis
5. Internal coherence Analysis

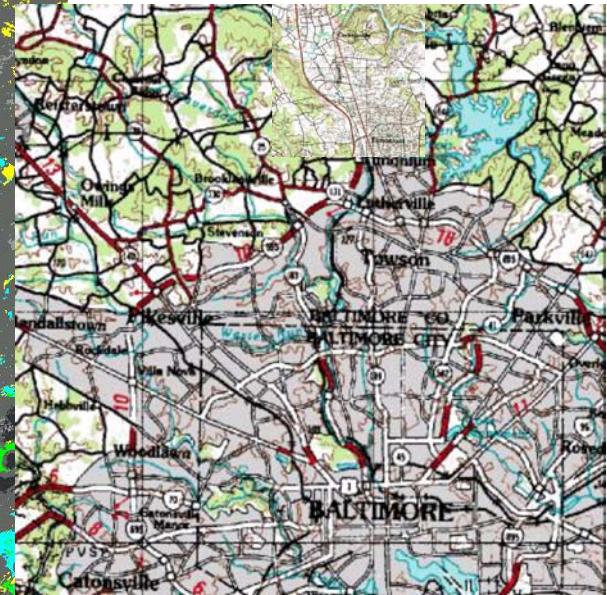
## Fusion of features derived from interferogram, intensity, height



## 2D: Urban Land Use from SRTM data

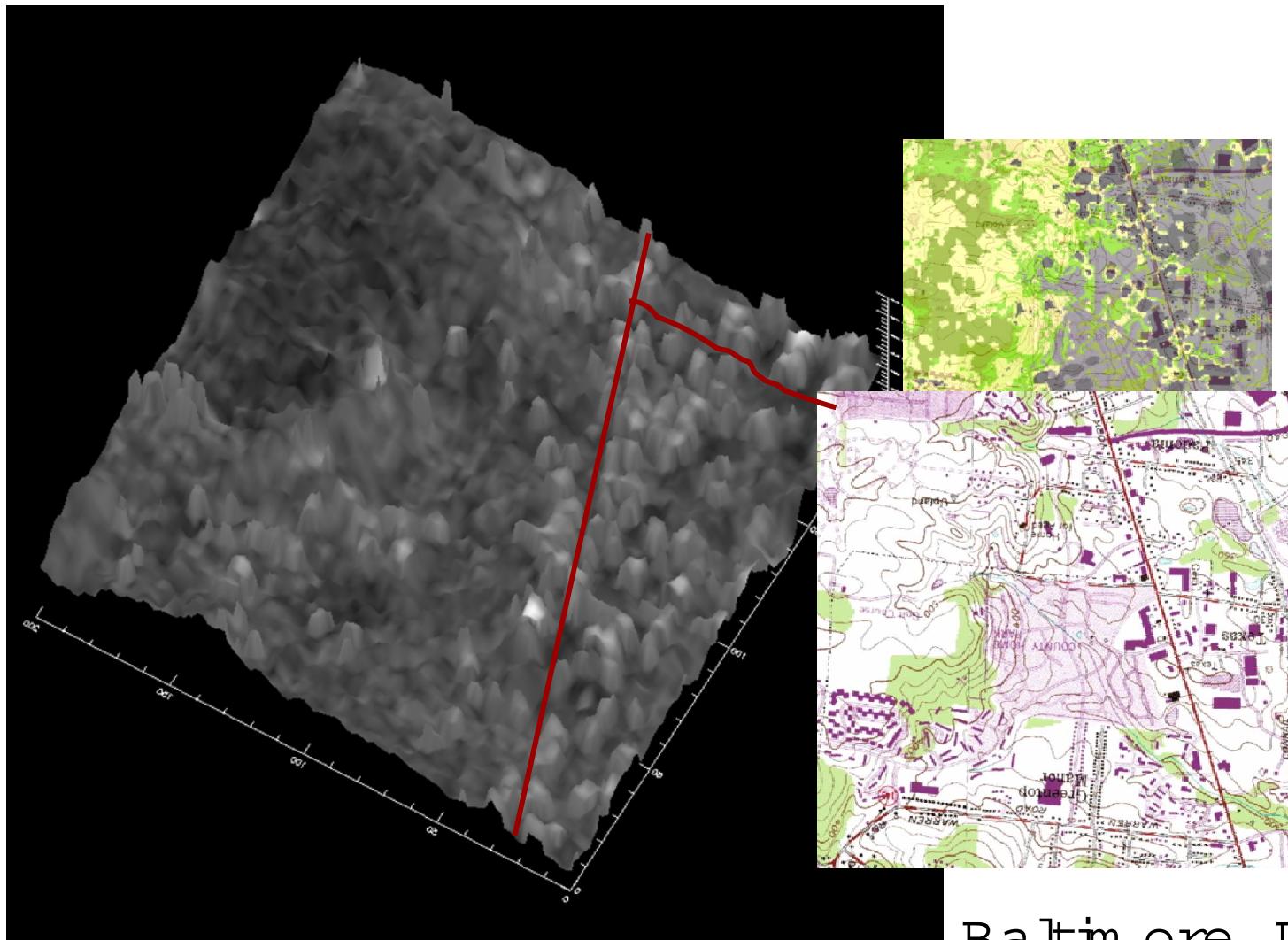


- dense urbanized
- medium urbanized
- light urbanized
- forest
- agricultural
- water



Baltimore, USA

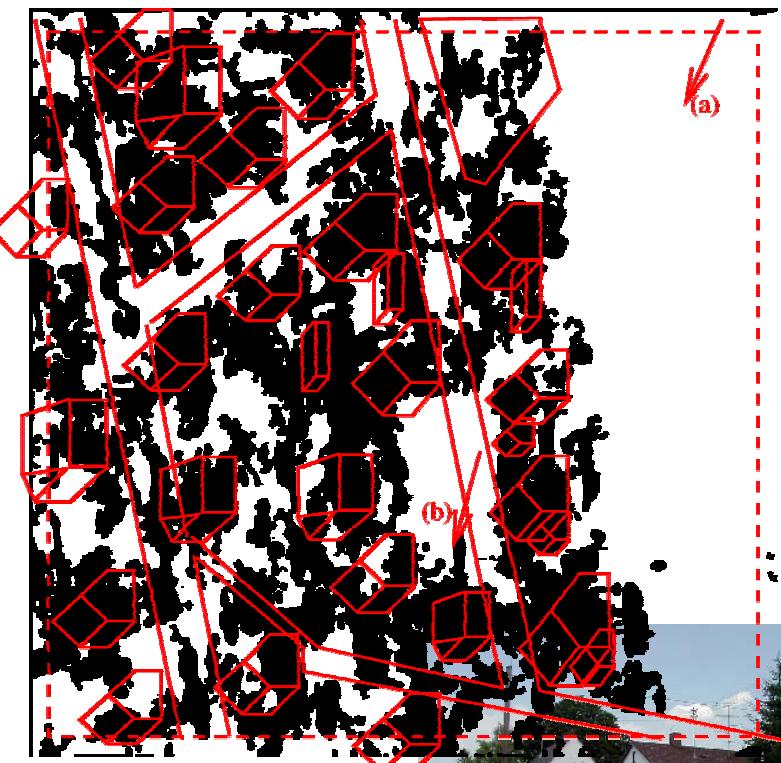
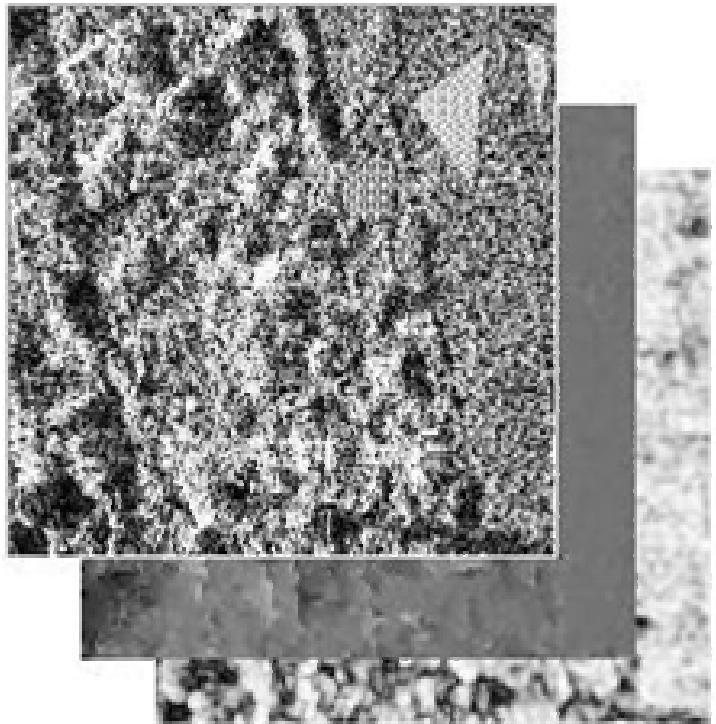
## 3D: Building detection from SRTM data



Baltimore, USA

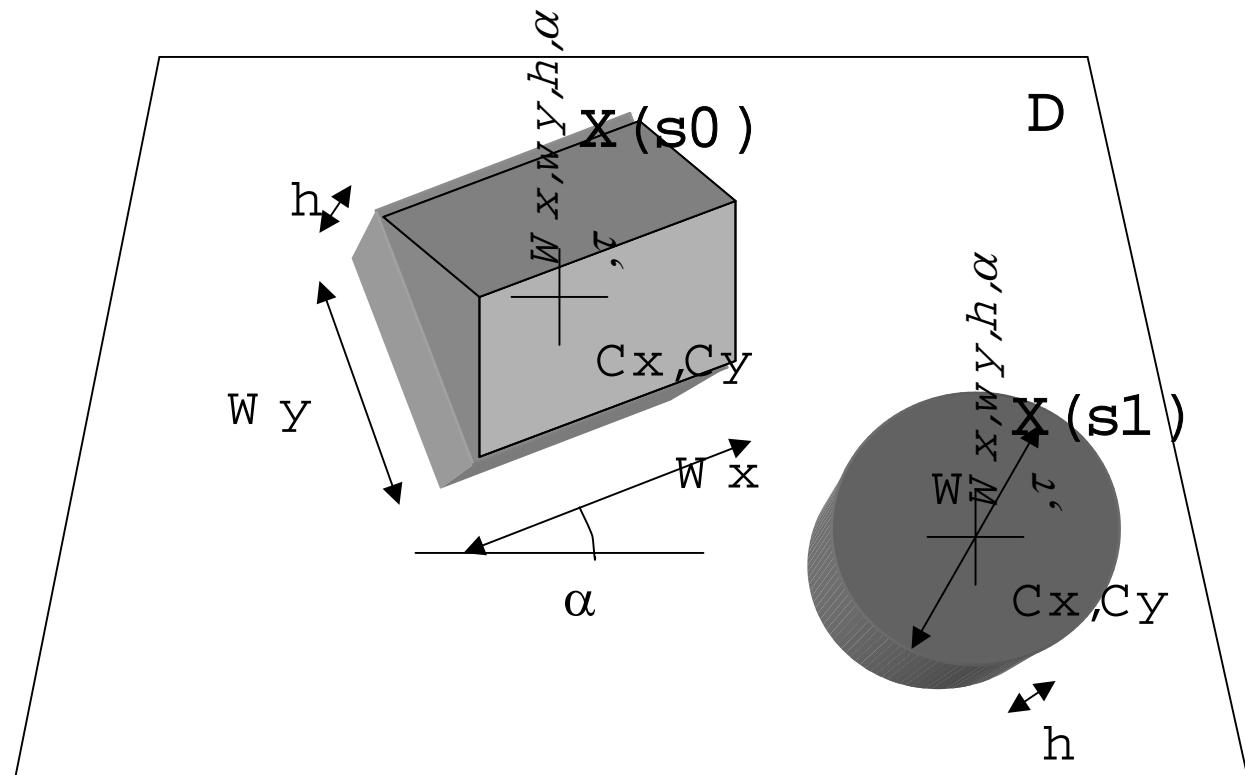
## 2D: Building detection through information fusion

Intermap Munich East, 0.5m

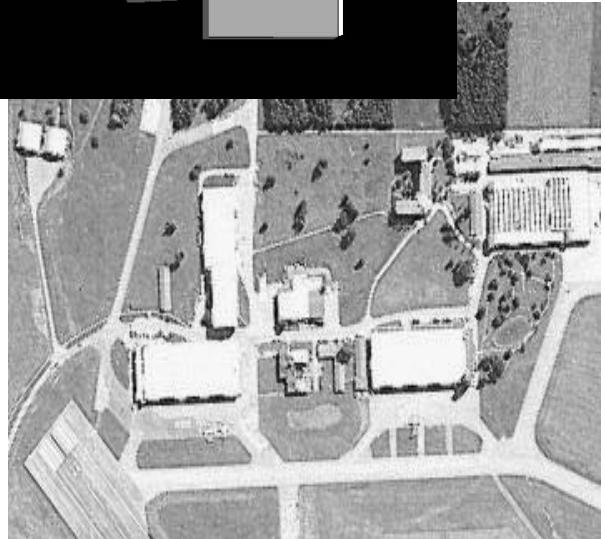
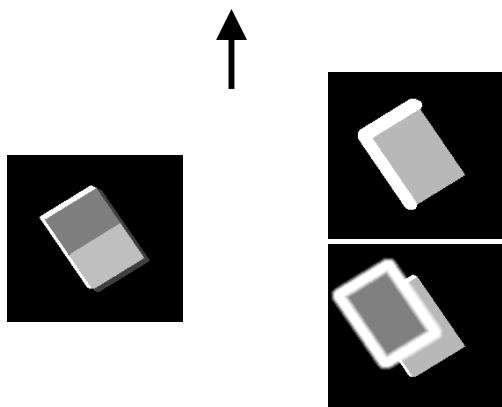
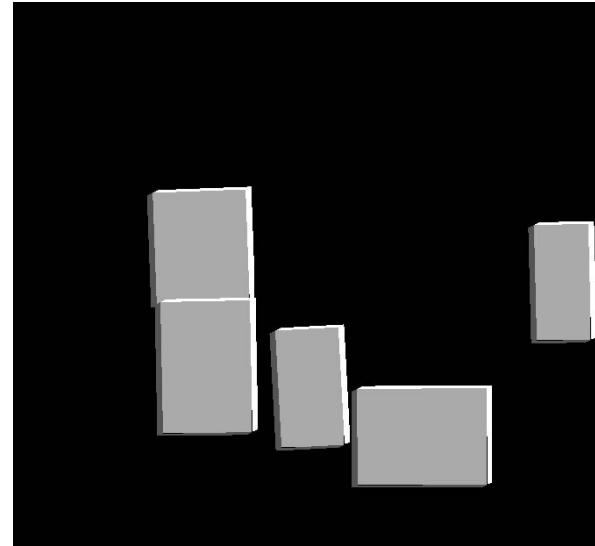
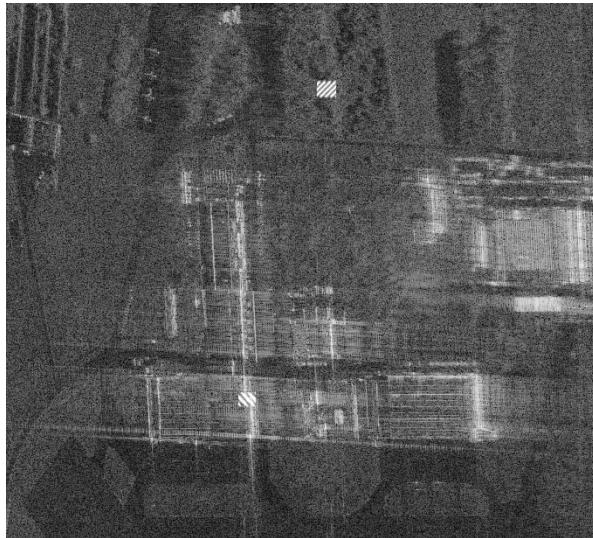


## Marked point processes

$$S = \{ X(s) : s \text{ in } D \} \quad X(s) = (w_i, h_i, \alpha, \tau)$$

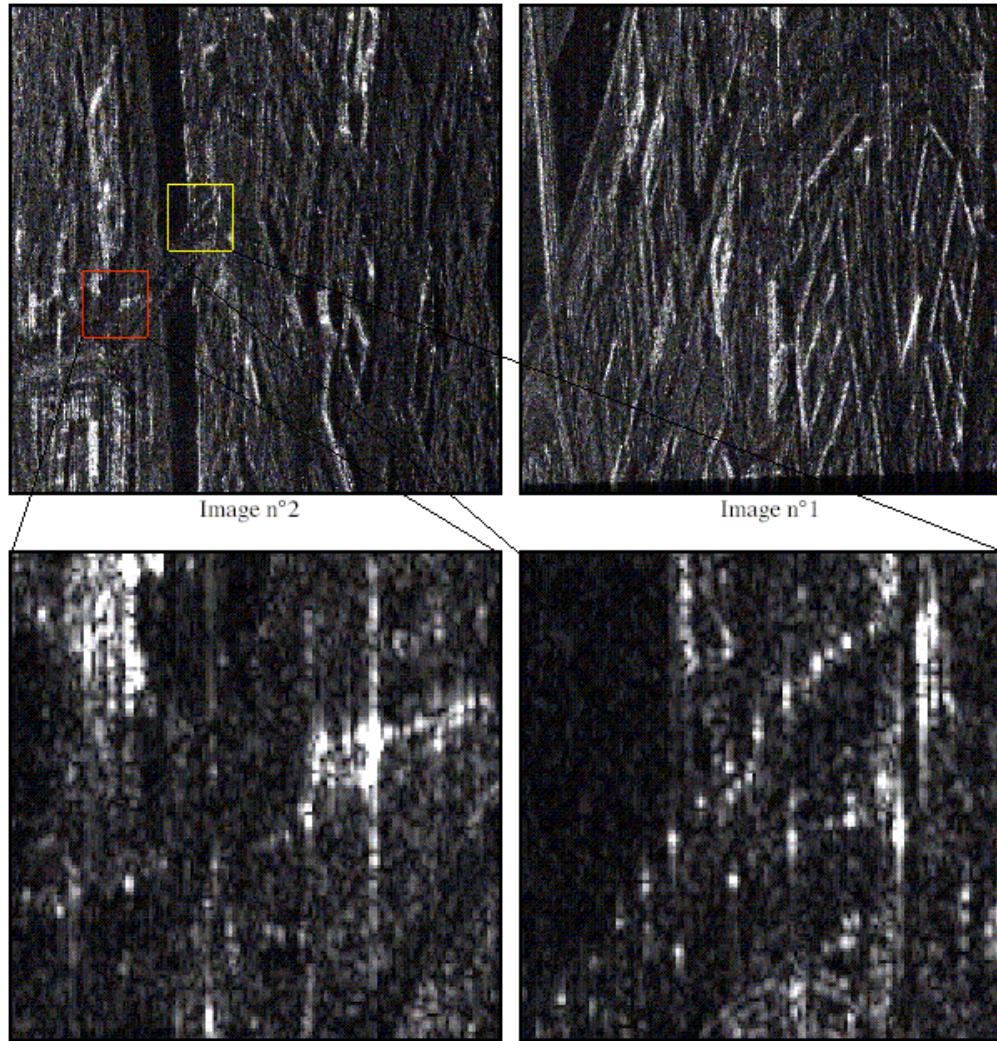


## Detection and recognition of industrial buildings

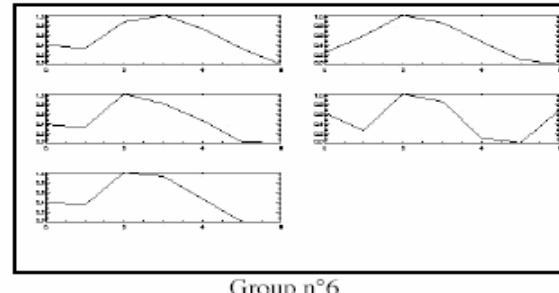
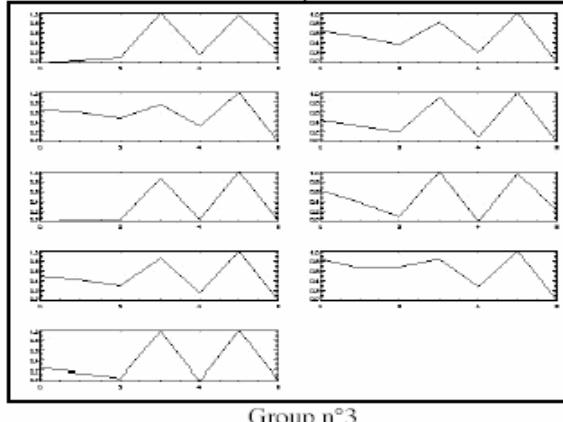
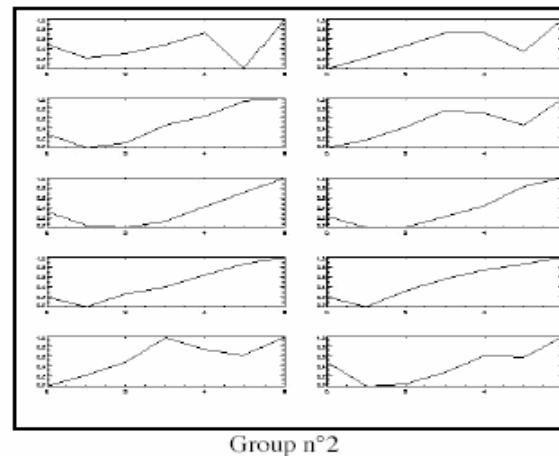
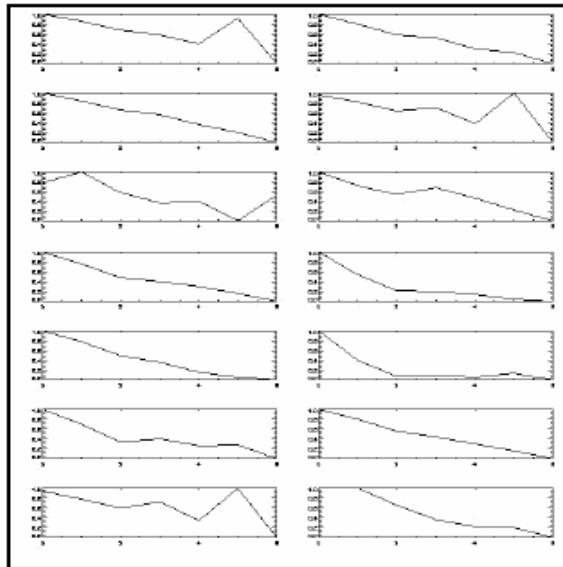


Intermap Oberpfaffenhofen, 0.5 m

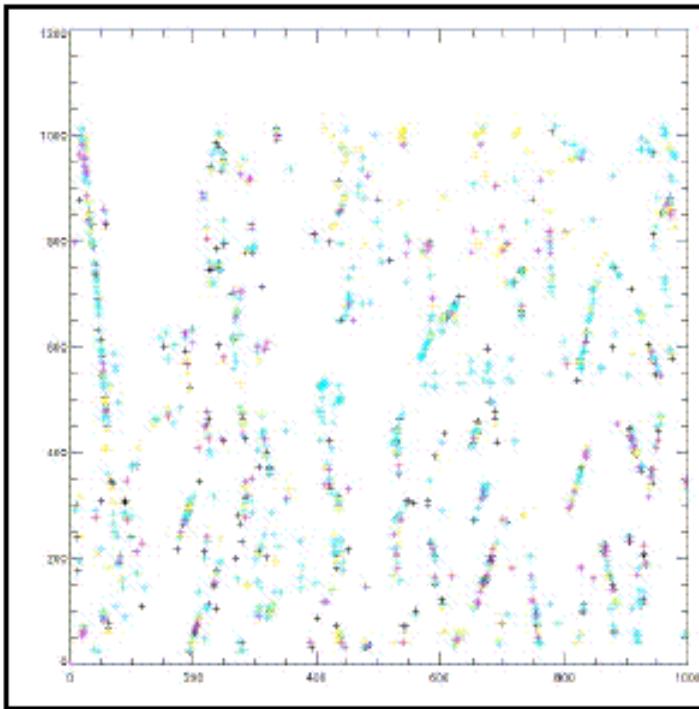
For urban scenes information concentrate in scattering centers



## Extract, select and group cepstrum signatures



## Targets clasification based on cepstrum signatures



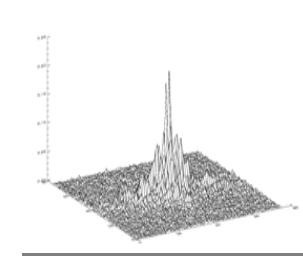
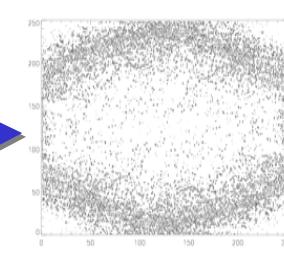
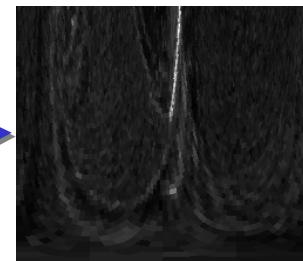
Normalized coefficients grouping for the image n°1; groups are (253, 666, 238, 168)

***Observation: good correlation with scene structures***

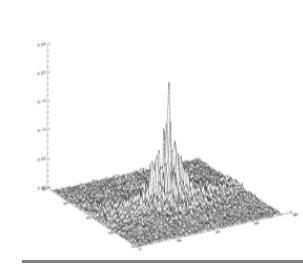
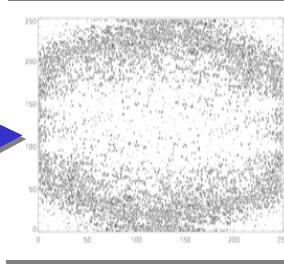
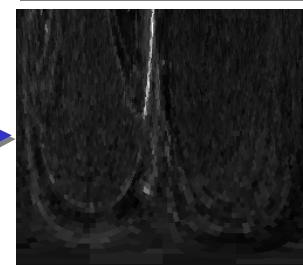
$$\mathcal{M}_{f_\sigma}(k, v) = \frac{1}{2\pi} \int_0^\infty \int_0^{2\pi} f(r, \theta) r^{\sigma - iv} e^{-ik\theta} d\theta \frac{dr}{r}$$

*log polar*

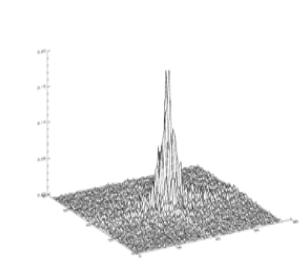
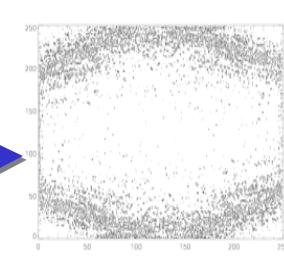
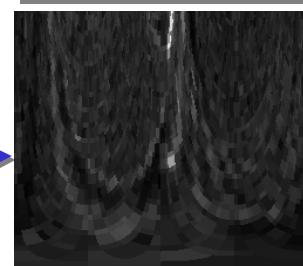
*Fourier Transform*



**Rotated  
33 deg**

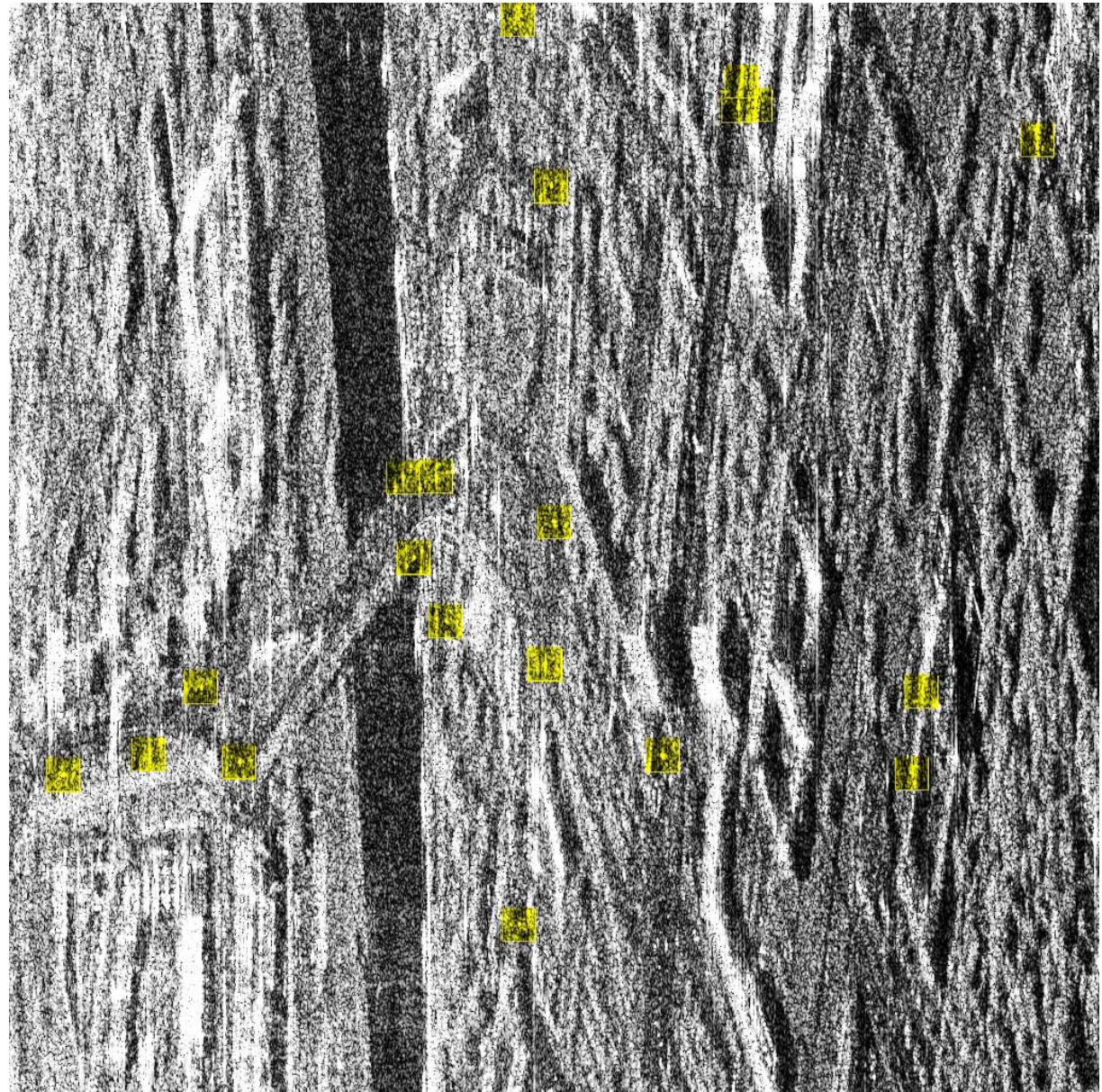
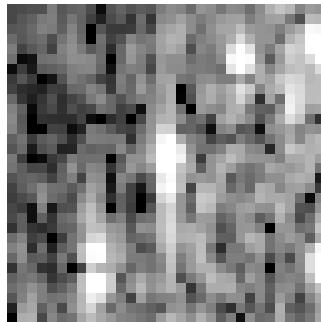


**Scaled  
150%**



**Rotation, scaling invariance**

*Target detection  
and recognition  
Example 1*

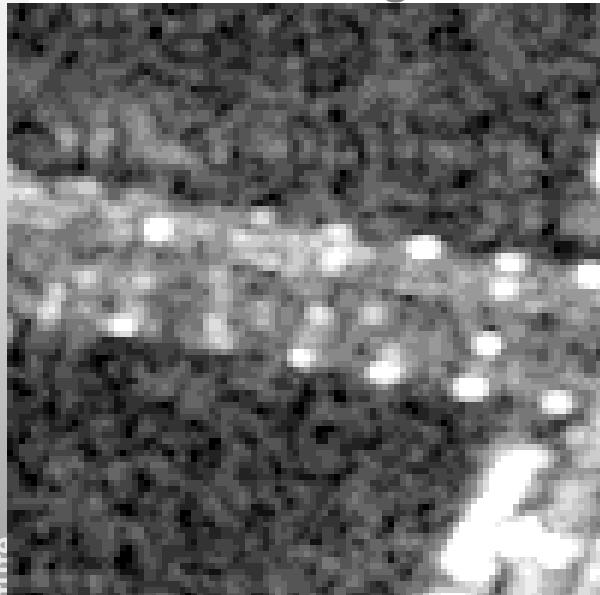


*Dresden,  
E-SAR  
X band 2m*

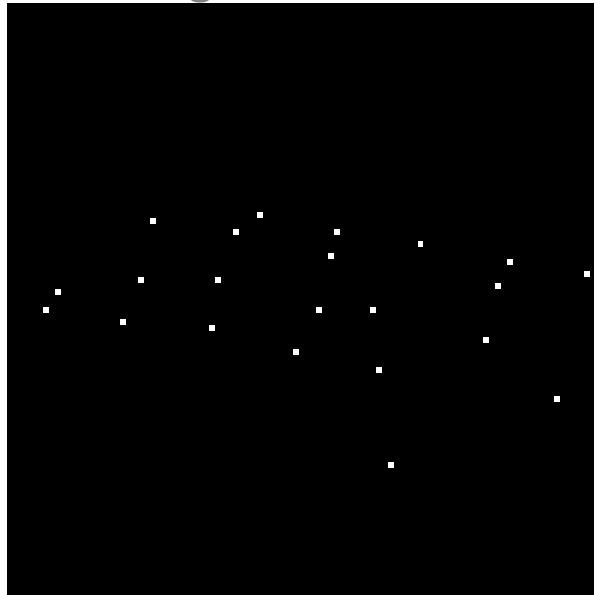
# Fourier – Mellin Analysis

## Recognition of scene elements: bridge

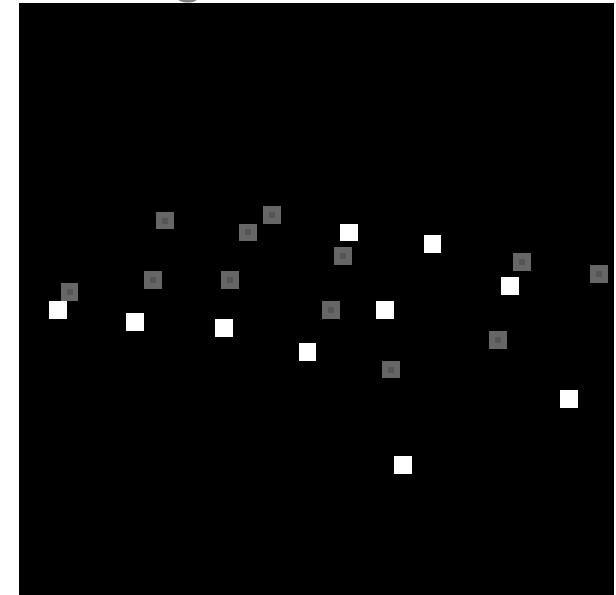
SAR image



Target detection



Target classification



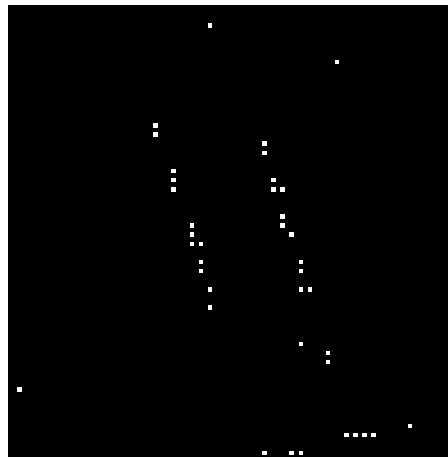
*Dresden,  
E-SAR  
X band 2m*

## Building characterization: base and roof scattering

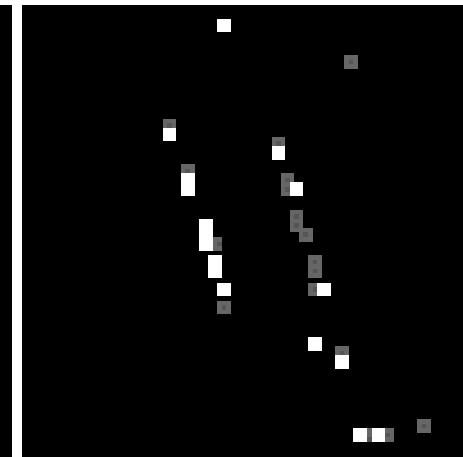
SAR image



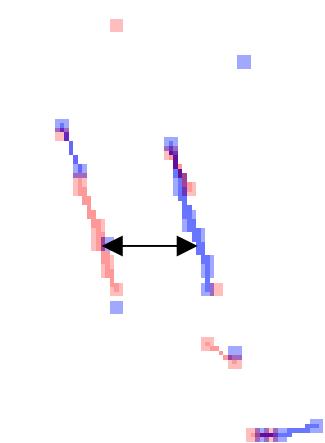
Target detection



Targets classification



Targets grouping



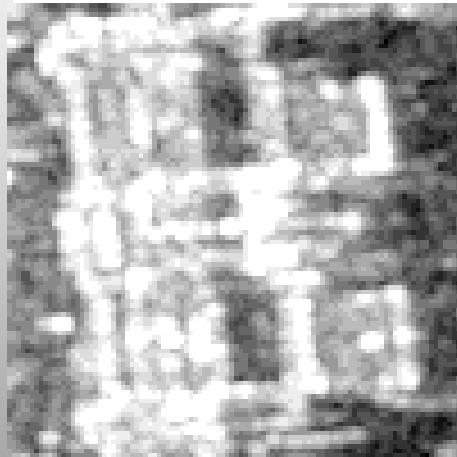
Estimated building height: 14 meters  
(consistent with LIDAR)

*Dresden,  
E-SAR  
X band 2m*



## Building elements recognition

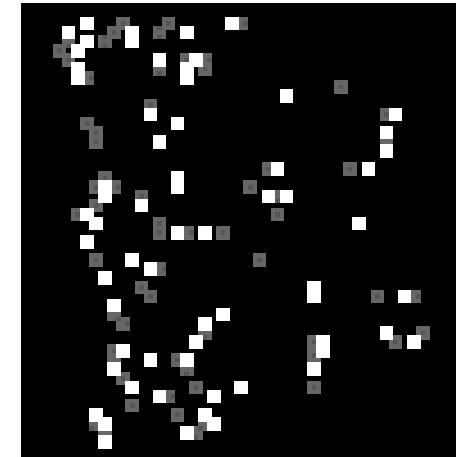
SAR image



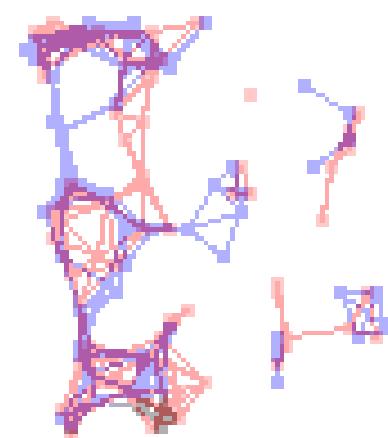
Target detection



Target classification



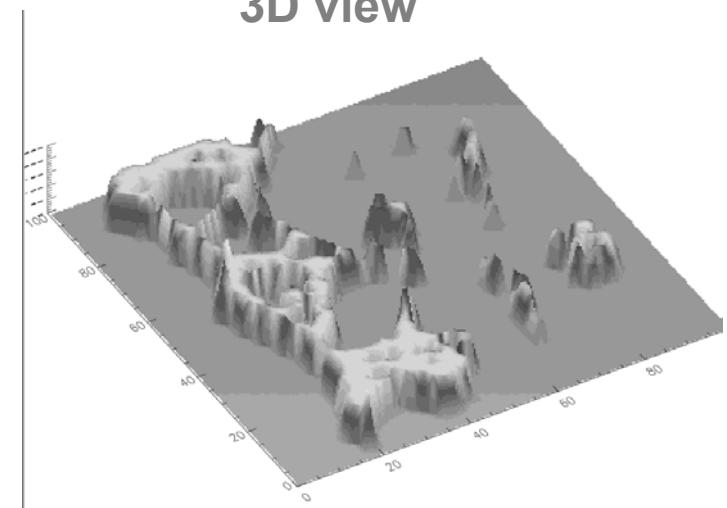
Targets grouping



*Dresden,  
E-SAR  
X band 2m*



3D view



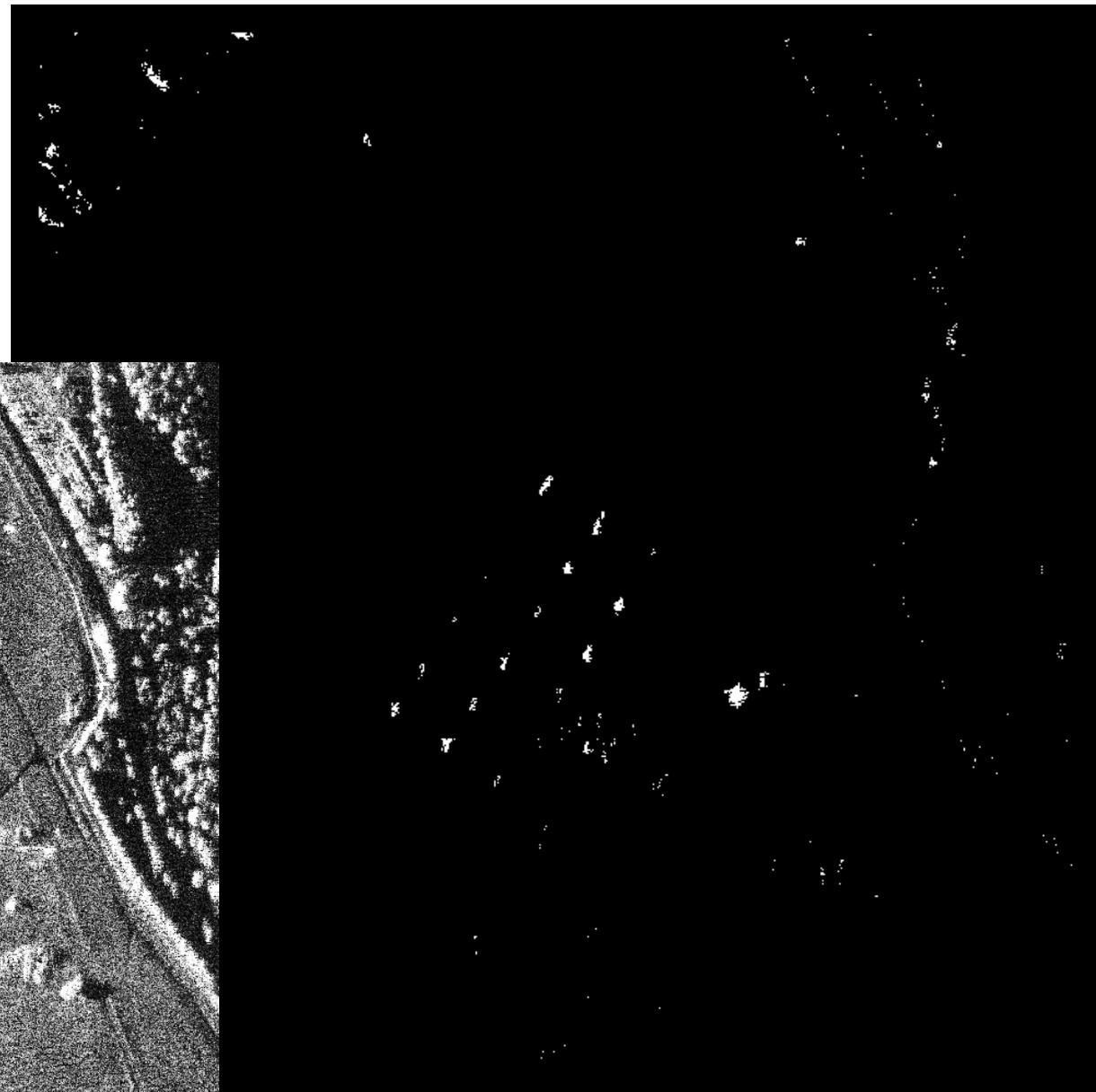
Target detection 1



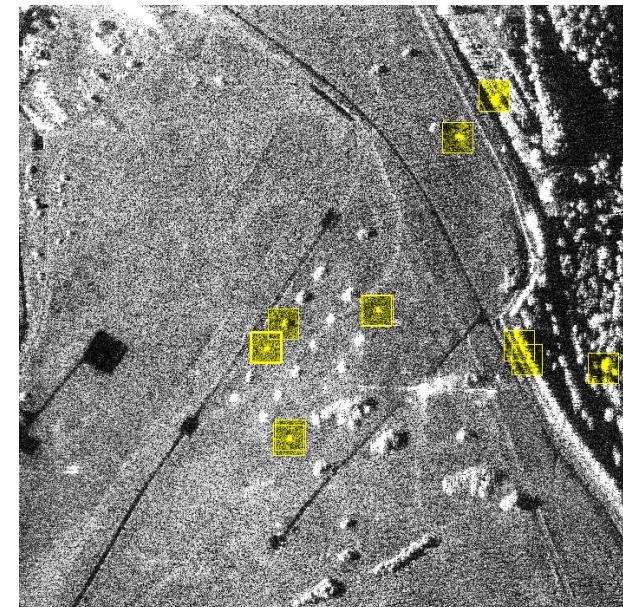
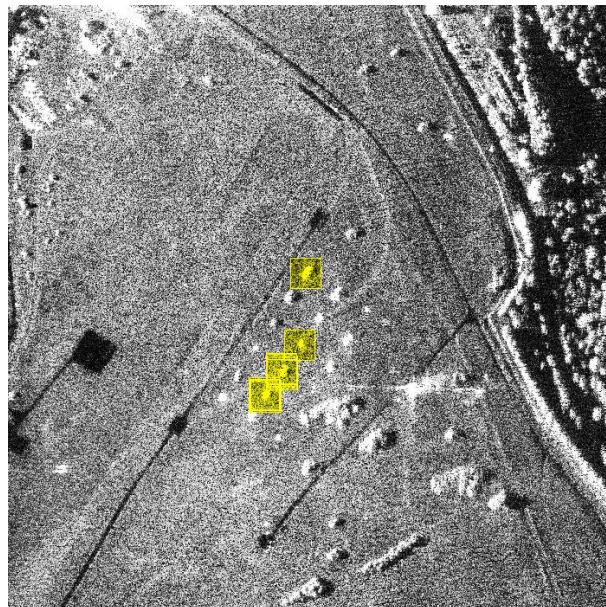
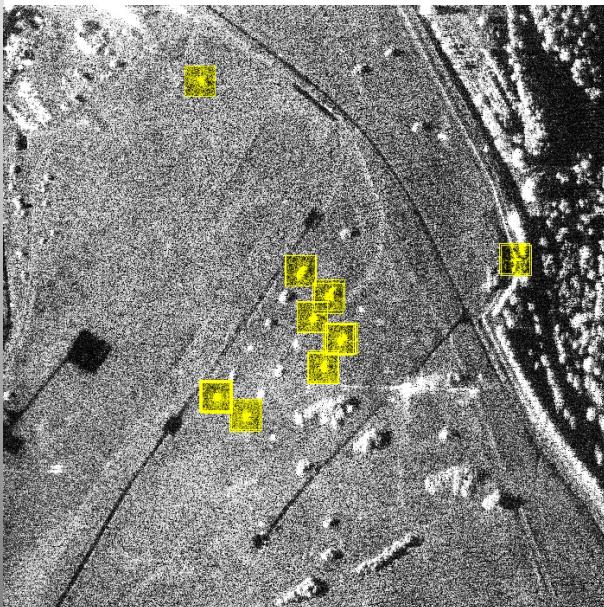
*FGAN SAR  
HH channel*



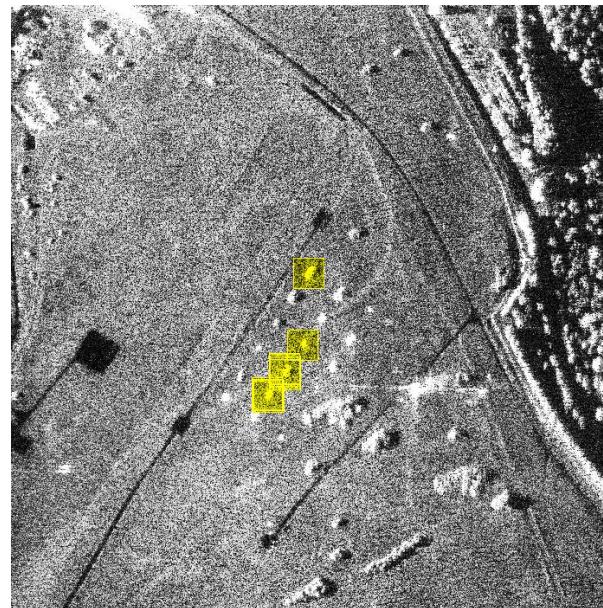
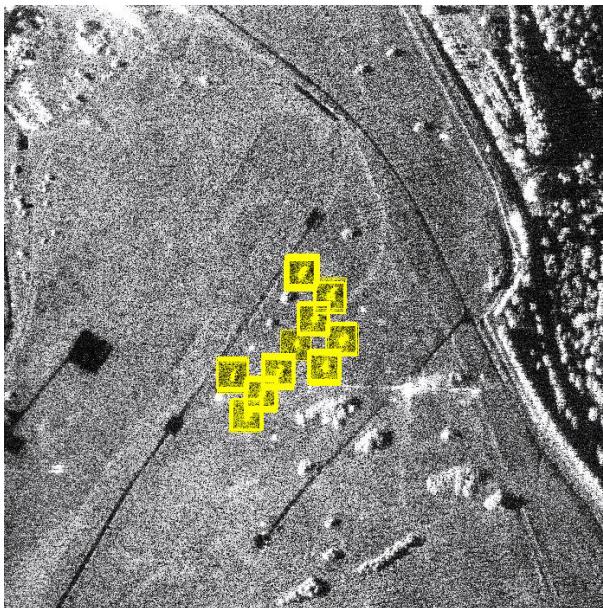
## Target detection 2



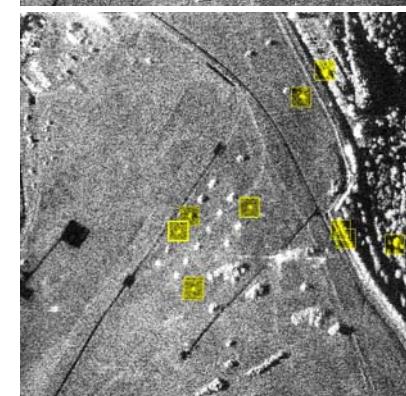
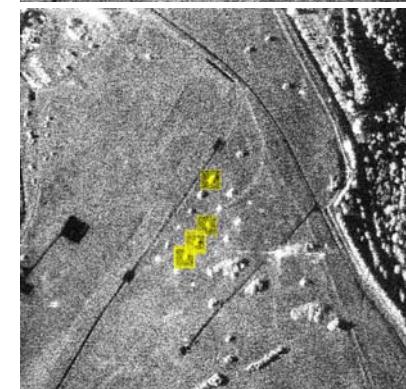
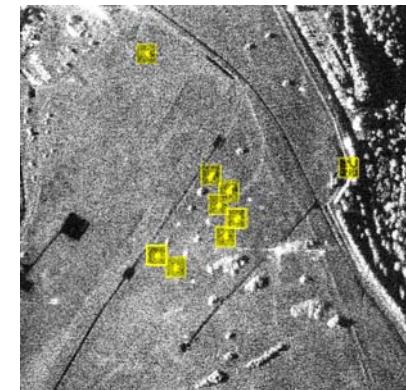
## Target classification (HH channel)

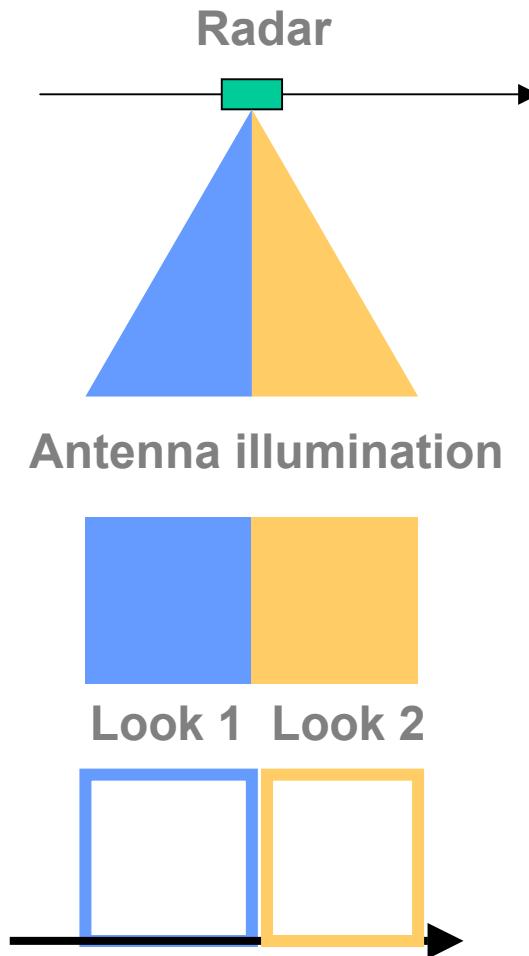


## Target classification (PolSAR)



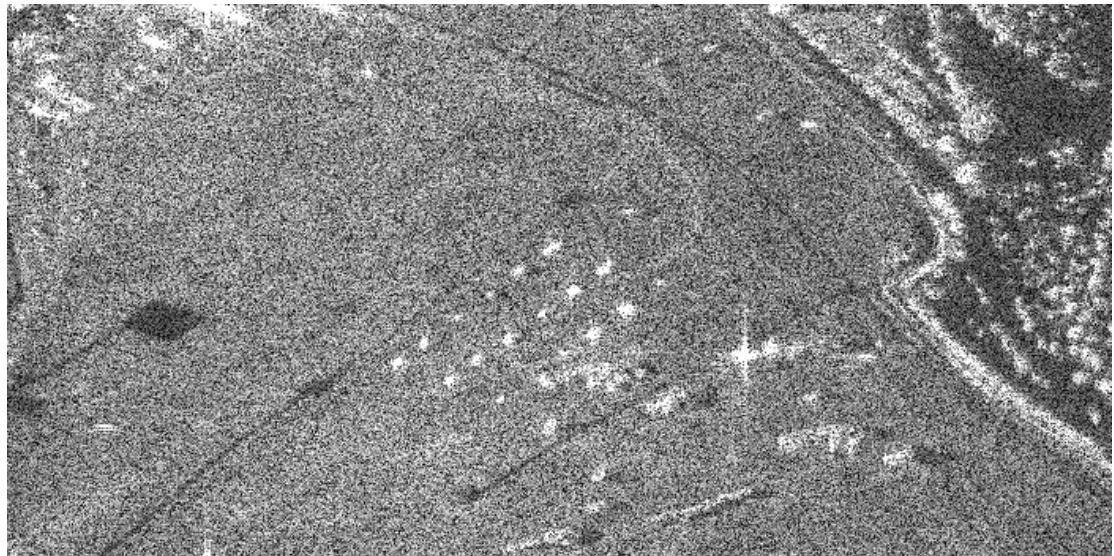
HH channel



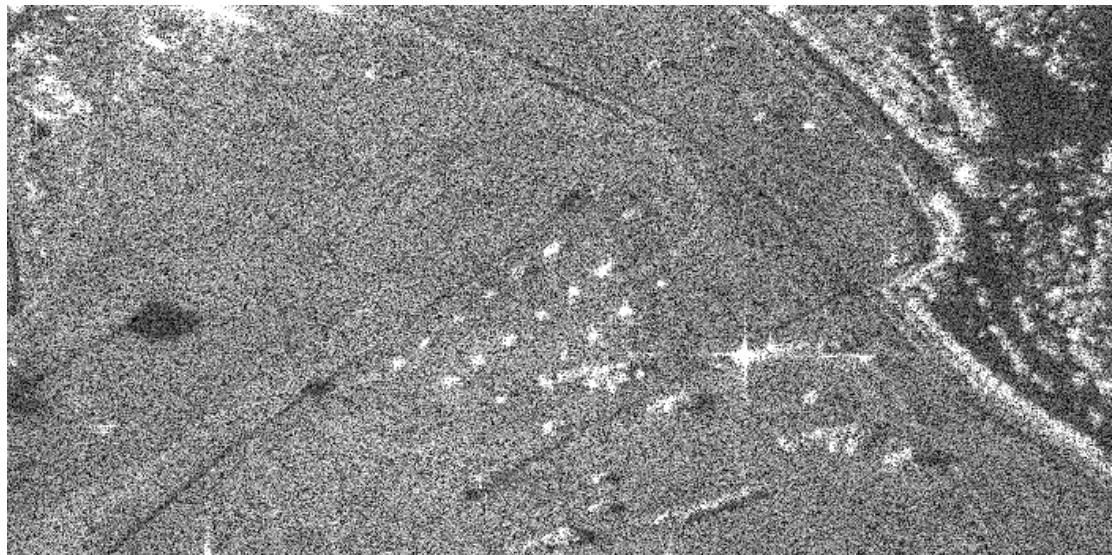


$$\rho_{int} = \frac{\langle s_1 \cdot s_2^* \rangle}{\sqrt{\langle |s_1|^2 \rangle \langle |s_2|^2 \rangle}}$$

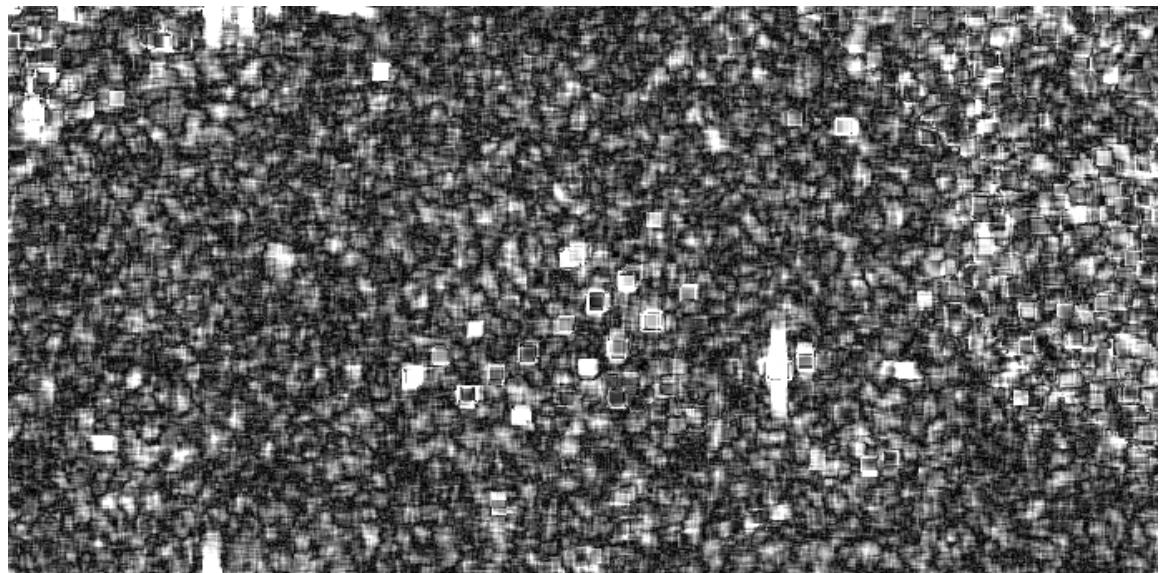
Look 1 (HH channel)



Look 2 (HH channel)



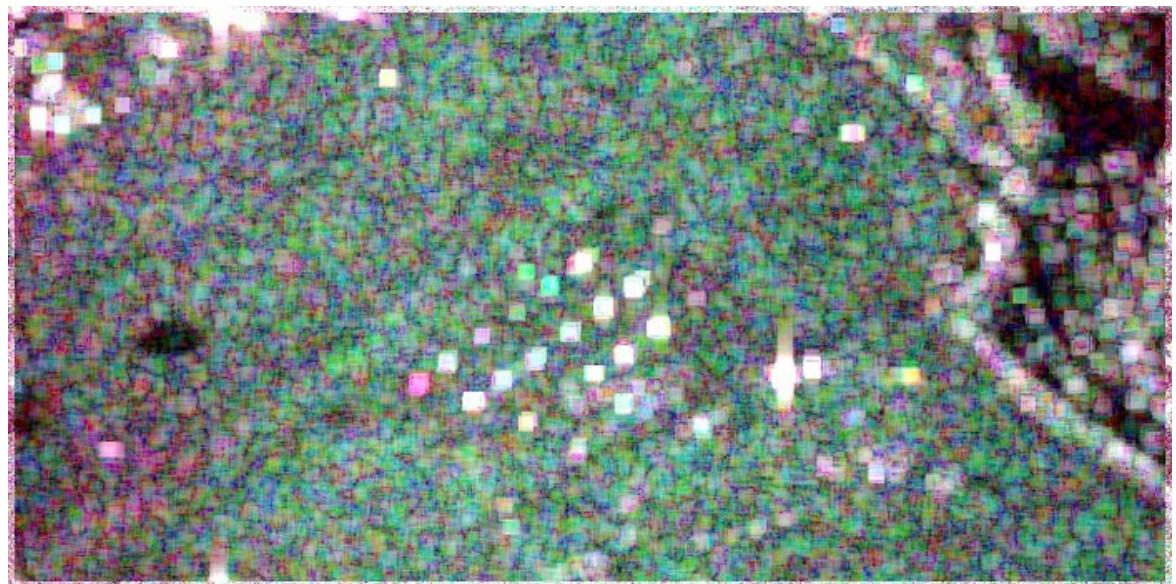
Coherence  $HH_1^*HH_2$



Coherence  $HH_1^*HH_2$

Coherence  $HH_1^*VV_2$

Coherence  $VV_1^*HH_2$



# Knowledge Driven Image Information Mining **KIM** Knowledge Enabled Services **KES**

On line demo

**<http://kes.acsys.it/kimv>**

**Members:** ASI, CNES, CNR, DLR, EC-IST, ESA, ETHZ, EUSC

**Chair:** Sergio D'Elia, ESA/ESRIN

**IIMCG focus:** research and technological activities for automated and user centred extraction of information from EO images and image archives in support to content understanding

### Events:

ESA-EUSC 2002: Joint seminar on Knowledge driven Information Management in Earth Observation data, ESRIN, Frascati, December 5-6, 2002, Madrid, March 17-18, 2004

**ESA-EUSC 2005: Theory and Applications of Knowledge driven Image Information Mining with focus on Earth Observation, ESRIN, Frascati, October, 2005**



## Scene Understanding for High Resolution SAR

**Mihai Datcu**

German Aerospace Center

DLR

Remote Sensing Technology Institute IMF

Oberpfaffenhofen

D-82234 Wessling

GERMANY

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**Scene Understanding for High Resolution SAR**

